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Technical Note: Improving the workflow in a carbon ion therapy center with custom software for enhanced patient care

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ABSTRACT

Carbon-ion radiation therapy (CIRT) is an up-and-coming modality for cancer treatment. Implementation of CIRT requires collaboration among specialists like radiation oncologists, medical physicists, and other healthcare professionals. Effective communication among team members is necessary for the success of CIRT. However, the current workflows involving data management, treatment planning, scheduling, and quality assurance (QA) can be susceptible to errors, leading to delays and decreased efficiency. With the aim of addressing these challenges, a team of medical physicists developed an in-house workflow management software using FileMaker Pro. This tool has streamlined the workflow and improved the efficiency and quality of patient care.

Introduction

Radiotherapy is a commonly used therapy for the treatment of cancer. Heavy ions, such as carbon, have gained popularity in recent years due to their unique physical and radiobiological properties compared to conventional radiotherapy. Carbon-ion radiation therapy (CIRT) is a treatment modality that uses carbon ions to target and destroy cancer cells with high precision and accuracy. The Bragg peak in CIRT allows for the delivery of a high dose to the tumor while minimizing the dose to surrounding healthy tissue [1,2]. CIRT delivery is a complex process requiring coordination between several healthcare professionals. Each team member plays an important role in the treatment process, and seamless communication among team members is essential to ensure treatment success.

The workflow for CIRT [3] is complex and involves many processes, including patient data management, treatment planning, scheduling, and quality assurance (QA). These complex workflows can be time-consuming, leading to delays in patient care and decreased efficiency [4]. Maintaining patient safety, clinical efficiency, and timely start of treatments requires effective staff communication [5], appropriate staffing levels, efficient workload distribution among resources, and process automation [6]. The use of custom software tools has the potential to streamline institutional-specific workflows and boost clinical efficiency. Previous studies have demonstrated that electronic whiteboards [7–9] and carepath management systems [10] can enhance communication and task coordination in radiation oncology. To address these challenges, a team of medical physicists developed a software tool to improve the workflow at a carbon-ion facility using FileMaker Pro (Claris International Inc., Sunnyvale, CA). Figs. 1 and 2 show the workflow of CIRT and the modules in the custom software. The different modules available in the software are discussed below:

Consultation

Patients complete a questionnaire regarding their medical history using a version of FileMaker, FileMaker Go, installed on an iPad (Fig. 1-a). Physicians use the responses from the questionnaire to assess the patient during the initial and follow-up consultations and address any concerns.

Schedule

Before scheduling patients, dummy time frames can be generated automatically using predefined rules through a scripting function or set

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manually. The physician selects the appropriate timeframe from the preset options. Subsequently, the physician will include the supplementary information necessary for treatment. The booked timeframe can be viewed on a calendar display (Fig. 1-b) and is added to the electronic medical record (EMR) to facilitate patient management.

Fixation

CIRT patients are immobilized using devices that allow precise positioning and reproducibility between treatments. Some of these devices are regularly reused for patient immobilization, making it important to track their utilization. The software (Fig. 1-c) manages patient immobilization device usage, reducing the risk of errors in device allocation.

Imaging

To facilitate a clear overview of the different processes, like imaging, treatment planning, and follow-up examination, in the workflow, the software provides an easily accessible visual representation in a daily or weekly view (Fig. 1-d). Because the radiation information system (RIS) lacks room-specific reservation management capabilities, the visual representation of activities in a daily or weekly view (Fig. 1-d) in the software is beneficial for the staff.

Other tasks handled in the software include the input of couch coordinates during CT scans, used for calculating couch parameters for patient positioning in the treatment room, monitoring changes in bladder volume over time, importing respiratory data [11], and communication between the treatment planning staff.

Treatment planning

CT images for multiple patients are obtained daily, each with a specific treatment planning deadline, and imported into the treatment planning system (TPS) [12–17]. Physicians utilize the software to visualize the progress of treatment planning for a particular patient and prioritize tasks (Fig. 1-e-1).

The gated treatment analysis helps determine a patient's optimal treatment parameters (Fig. 1-e-2). This analysis establishes a relationship between the respiratory waveform data collected from the body surface and the target's center of gravity at various respiration phases, as acquired from the TPS. From selected 4DCT phases, the internal target volume (ITV) and the irradiation gate level are obtained [18].

Conference

Most CIRT facilities have implemented chart round [19,20] meetings where patient treatment plans are peer-reviewed as a quality control measure. During the chart rounds meeting, key elements from the treatment plan are presented for discussion (Fig. 2-a). The software allows for a comprehensive review and discussion of each patient's treatment plan, thus enhancing patient safety and plan quality.

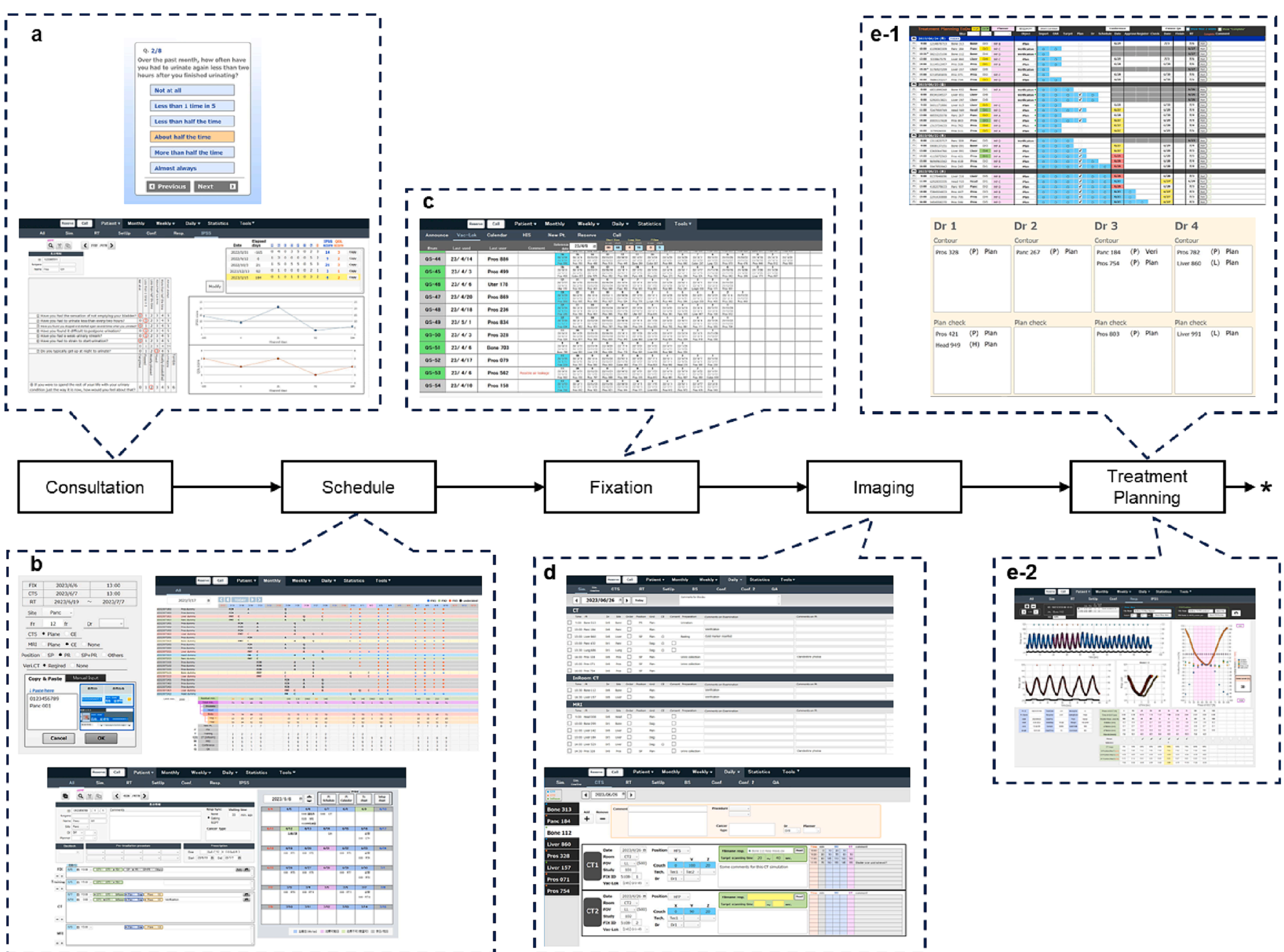

Fig. 1. CIRT workflow showing different modules of the custom software.

Registration

The information from the TPS is imported into the software in text format, allowing the physicists to perform a semi-automated treatment plan check (Fig. 2-b). The weekly display page (Fig. 2-b) provides the irradiation schedule for each treatment fraction. Many factors, such as the availability of treatment rooms, planned ports for irradiation, and schedules of other patients, are considered when scheduling patients.

Patient-specific quality assurance

Patient-specific quality assurance (PSQA) using a log-file approach is utilized at many CIRT facilities because it can reduce the time required for measurements [21–23]. As part of the PSQA schedule (Fig. 2-c), therapists perform an exposure of the scheduled beam, and the resulting log files are subsequently subjected to gamma analysis [24]. The software integrates the analysis data and helps streamline the scheduling and documentation of the PSQA sessions.

Treatment

A real-time status change of the patient's arrival is visible on the treatment room list page (Fig. 2-d), informing the therapists that the patient has arrived for treatment. All the necessary information about the patient's treatment can be visualized to aid the therapist. A graphical representation of the patient's imaging shifts and positioning (Fig. 2-d) is also provided.

Follow-up

Treatment progress is monitored from the consultation room. Patients are referred to the consultation room from the waiting room after treatment (Fig. 2-e). Audio announcements and instructional videos inform and prepare patients for their upcoming treatment (Fig. 2-e), resulting in a seamless and informative experience.

Discussion

The in-house software is an essential component of the CIRT workflow and treatment management. The system enhances efficiency and effectiveness by facilitating information sharing, expediting routine tasks, and minimizing errors. Unlike commercial systems, the software enables adding functions and modifications, saving significant time and costs that would otherwise be required for such adaptations. The software excels in data management, allowing users to output vast amounts of data in various formats, such as text or comma-separated values, and facilitate tasks, such as patient statistics, setup error analysis, and dose constraint evaluations.

However, compared with other systems, the current version of the software has some limitations, particularly in terms of scalability. System development within FileMaker relies on its user interface, which can constrain advanced functionalities. Additionally, processing speed can

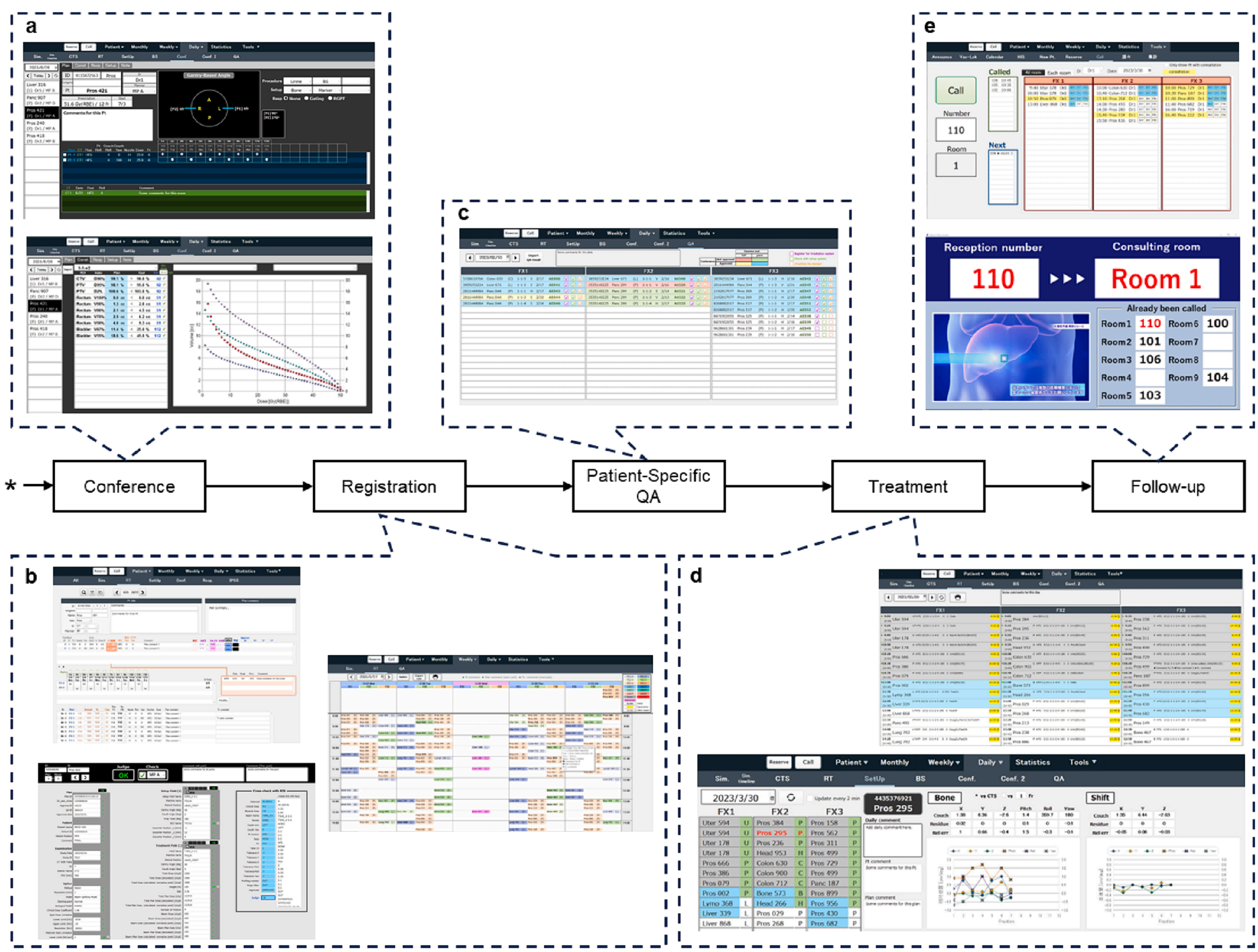

Fig. 2. CIRT workflow showing different modules of the custom software (continued).

decrease as the database capacity increases, resulting in delays. Hence, it would be beneficial to integrate other database management systems after the initial development using FileMaker to enhance processing speed when handling larger datasets.

Establishing direct communication between the current system and a commercial RIS poses challenges. It is important to note that while integration with a commercial RIS might be complex, a viable solution exists. If the RIS can export reservation data, this information can be incorporated into the software. The interoperability of exporting and importing reservation data from the RIS allows for exchanging information, reducing redundancy, and ensuring that the two systems work together. This integration streamlines the processes and provides a more comprehensive patient management experience.

Conclusion

In conclusion, the software can improve the workflow at CIRT facilities. The ability to adapt and modify functions on a case-by-case basis aligns well with the complexities of radiotherapy, thus making it a valuable tool. Although challenges exist, they can be overcome with premeditated system development and integration, ensuring continued excellence in CIRT.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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